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Short Paper

Data visualization of decoration occurrence and distribution. A comparative study of Late Egyptian funerary decoration in Thebes.

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Abstract

Decoration in Ancient Egyptian funerary monuments represents an important part of the monuments layout. Beside scenes displaying the owner, scenes of daily life, fabrication, offerings and hieroglyphic texts are found. Not only topics of self-presentation but also decoration for the translation to the afterlife were predominant. Therefore, this paper suggests approaches to analyze distribution and occurrence of decorations of several ancient monuments of the same style, with data visualization and quantitative methods. As a case study ancient Egyptian funerary monuments of High Officials from the Late Period, twenty-fifth to twenty-sixth dynasty, were studied. The decorative scenes were categorized and tagged in terms of their content. The positions in the monument were highlighted and included in abstracted 3-dimensional models. This computational implementation offers users to search for decoration categories, highlight, locate and finally compare the position of a scene between the monuments. The visualized data include the position and orientation of a categorized scene in the monument, their occurrence and distribution among the analyzed monuments. In a further step the analysis data was studied statistically in order to be able to query detailed results of the prevalence, distribution and preservation of decorations and specific scenes. Both introduced solutions provide a user friendly information interface to visualize, compare and request quantitative data.

CCS Concepts

•***Mathematics of computing*** → *Statistical software;* •***Human-centered computing*** → *Visual analytics;*

1. Introduction

Decoration in Egyptian funerary monuments and tombs did not only fulfil the purpose of being decorative. Because the Egyptian people believed in an afterlife, the decoration can be categorized into two classes: decoration for self-presentation in life and decoration for translation to the afterlife [Sna11]. To study the decoration of Late Egyptian funerary monuments at Thebes (modern Luxor) the decoration data was transferred into a digital format to acquire knowledge of the decoration program: In the first section of this paper it is discussed how to handle the decoration of a group of funerary monuments of same style. The main question is how to compare the decoration of a monument and visualize the data, in order to provide a comparison between the structures. Additional, the data is presented in graphs using R, in order to compute occurrences of the scenes.

The monuments are of the same style and were build during the twenty-fifth and twenty-sixth dynasty. They belong to the type of rock-cut funerary monuments. The owners of the funerary complexes were High Official with a high social status and considerable political leverage. The analyzed complexes are located at the westbank of the ancient city of Thebes (modern Luxor). The structures are partially damaged, because of serious problems with the stone material in this area. Some of them were also used as modern houses or basements, which was not supporting the preservation situation of the structures. On the other hand, some structures were never finished, which is elucidated by undecorated walls and sketched but unfinished decorations. Anyway, in many parts, the rich and delicate decorations are still preserved. The decoration is diverse and partially numerous, due to the extent of some of the complexes.

2. Former Documentation of the Monuments

The earliest documentation of Late Period private funerary monuments dates to the 18th century, when [Poc43] visited the site. Further expeditions followed, like [Bel21], Hay (unpublished), [Cha68] and [Lep49]. In the 20th century excavations followed under [Win20] [Lec61], the Deutsches Archaeologisches Institut, the Oesterreichisches Archaeologisches Institut [Bie72] [BRH78] [BRH82], or the University of Rome [Don73]. Those documentations and contributions are currently updated by standalone excavations [Tir06], [Tir09], [Pis09], [Pis14], [Pis17]. In 1984 D. Eigner [ED84] published an overview of Late Period funerary monuments of Thebes. In his work Eigner renews and complements existing plans and reconstructions from monographs and building documentations in terms of manually shaped plans and geodesic data collected by J. Dorner.

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3. Research Objectives

Results and methods of previous studies of the decoration of Late Egyptian funerary monuments of Thebes are based on archaeological stand alone documentation and description. The current paper explores quantitative relations of the scenes as well as comparative information to gain new insights about the monuments decoration and its relation to the space. Specifically, the main research questions of this paper focus on:

How to identify and display the quantity of decorative scenes at the monuments? Which parameters like occurrence, layout, position or orientation of decorations can be extracted and can be compared between the monuments? Are the scenes ralated to the spatial layout of the monuments or the use of rooms? Does the accessibility and adjacency of spaces as well as natural lighting influence the occurrence of a scene?

4. Data Visualization

This paper includes the decoration data of six monuments: Harwa, Akhimenru, Karabasken, Irtieru, Pabasa and Ankh Hor. The funerary complexes consist of three levels of vertical construction (superstructure, substructure and burial area) (1). The rock-cut substructure consists of an entrance, an open-from-above courtyard, a niche entrance, and a rock-cut structure of one or two pillared halls and a sanctuary. The superstructure as well as the burial area are not part of the study because not every monument has a proven or documented superstructure and not all shafts and underground spaces of the burial area are excavated. To visually analyze the decoration

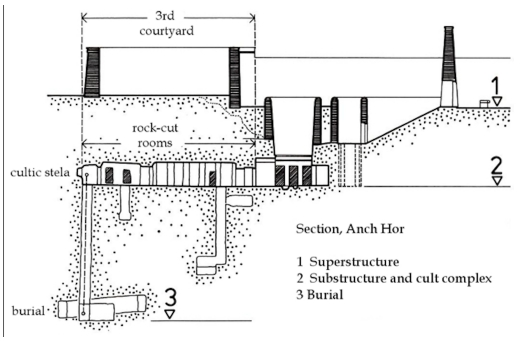

Figure 1: *Schematic drawing of the level structure of Late Egyptian funerary monuments at Thebes: superstructure, substructure, burial area [ED84].*

in space the data was integrated as metadata to a former implemented Space Model Comparison Tool (SMCT) [Wut15]. The tool was created to support the visualization of architectural analysis results in a realtime 3D development platform (Unity) and comparison of multiple Late Period funerary monuments based on spatial and social metadata. This tool already handles digitalized and visualized substructure of six substructures and is still expanded. The SMCT includes schematic space models enriched with graph-based space layout representations of evaluated spatial relations through HBIM methods [Sut15] [Wut15]. The models represent walls with a low level of detail. No textures are included. The emphasis of the models is on the representation of the analysis data, instead of a detailed reconstruction.

3-dimensional models are prepared in a commercial architectural BIM system. As modelling engine an Autodesk Architecture environment (CAD) complemented by a C++ implementation of a space modelling system was chosen (implemented by: [Sut13] [SPS14]). Therefore existing floor plans [ED84] and heights of the modelled spaces provided enough information needed to operate. For each funerary monument, modeled data includes spaces, openings, and doors. External and internal spaces are modeled separately to determine daylight access of spaces. Open courtyards, for example, are vertically adjacent to external air spaces that provide daylight access. Source space data is exported from the BIM system to a space modeling system and are imported back into the BIM system for visualization and evaluation [Sut15]. This spatial relation network is represented by nodes for layout elements and edges for spatial relation elements [SPS14]. Added metadata provides social information of the owner, time relation and space labels of the funerary monument. This data combined with the schematic space model and generated analysis results are providing the possibility to compare the monuments to each other (2).

With the SMCT also the untrained user is able to select different settings and arrangement selection via user interface to show different aspects of architectural analysis. In a linear setting the models are arranged in a linear way to directly combine their constructions. To arrange them in relation to their social metadata, the *Order* can be changed in terms of chronology, rank, gender etc. The selection *Space Model* provides different graph-based space layout representations of the spatial analysis results: Architectural, Natural Lighting, Pedestrian Circulation. The natural lighting space model selection offers in addition to the graphs (edges and nodes) a visualization of the natural lighting intensity. Spaces with a high intensity of natural light are represented with a light yellow and spaces with a lower intensity of natural light are visualized darker. The pedestrian space model selection visualizes the results of the generated pedestrian circulation view and is also additionally enriched with visual information. In this case the deepest space (in relation to the unit door) is shown in the darkest grey (2). In addition, color labels are

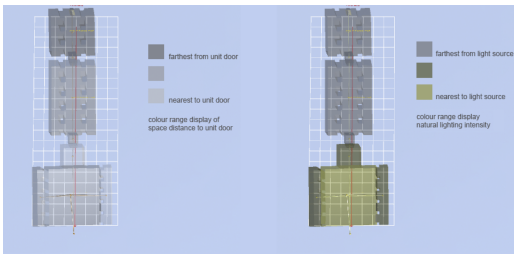

Figure 2: *Chromatic color coding for the pedestrian circulation and natural lighting results.*

included. They represent scene categories and subcategories and are defined with appropriate category-tags (4 and 3).r Within the individual user interface settings at the SMCT the user can choose a scene category or subcategory. The requested scene will then be highlighted at the corresponding positions in space. With this appli-

cation it is possible to locate specific scenes in the monuments and make comparative statements. Furthermore, detailed results about the position, orientation and relation to spatial arrangements of a decorative scene can be extracted. In combination with the function

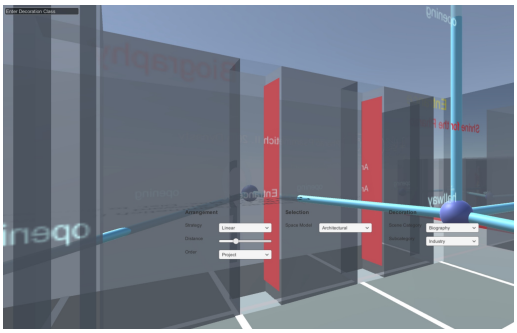

Figure 3: *Detailed view of the courtyard of Ankh Hor. Schematic 3D model, with integrated spatial analysis graphs, user interface and highlighted scenes of the category: Biography and subcategory: Industry.*

of color coding of space relationship analysis (natural lighting and pedestrian circulation), the visualization displays that the scenes were directly connected to the lighting and access system (4). This provides explicit information about the relationship of accessibility and decoration category in space. The analysis and visualization il-

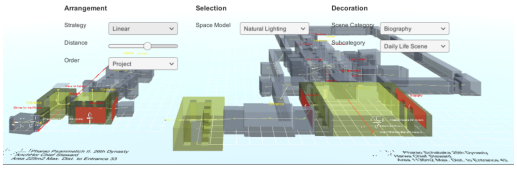

Figure 4: *View including Ankh Hor and Harwa. Highlighted Category: Biography and Subcategory: Daily Life Scene. Including color code for natural lighting intensity.*

lustrate that daily life scenes and offering scenes occur likely in lit and semi-public areas like the open courtyard and entrance area. The distribution if daily life scenes is shown in 4. Moreover, the results reveal that the natural lit spaces, such as the open courtyard, were at least semi-public and accessible to sacrifice the dead (6). The farther to the sanctuary along the straight main axis the less natural light was entering and simultaneously the more increased the sacred intensity. Those inner parts of the funerary complex were non-public and closable with doors [ED84] and likely sealed. The closable non-public and not lit rooms contain mainly verses to support the owner to afterlife. Anyway, also the courtyard can contain texts which prepare the deseased for the afterlife [Tay10]. These texts include magic spells from the Book of the Dead, an ancient Egyptian funerary text (5). At this point of data examination no results about the level of lighting at single walls can be stated. The presented results pertain to the lighting situation of the spaces.

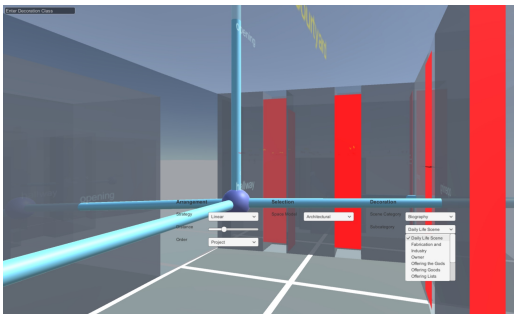

Figure 5: *Detailed view of the courtyard of Ankh Hor. Schematic 3D model, with integrated spatial analysis graphs, user interface and highlighted scenes of the Book of the Dead.*

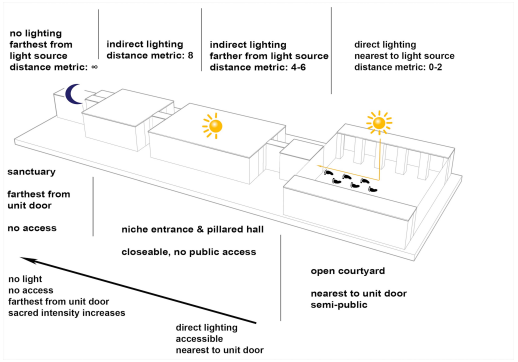

Figure 6: *Summarized results for the spatial analysis: natural lighting and accessibility.*

5. Quantitative and Comparative Information

Additional, the data is presented in graphs using R in order to provide quantitative information of scenes as well as its occurrence.

The input is collected as a data.frame named *decorationinfo*. The dataframe is the two dimensional data structure in R and is accessible like a list (7) or like a matrix. It is created with the data.frame() function. *Decorationinfo* has four components including general information (category, room, monument, preservation). The scene *categories* contain: Daily Life Scene, Fabrication and Production, Owner, Fabrication, Offering Goods, Offering the Gods, Offering List, Htp dj njswt offering, Book of the Dead, Text, Statue of a God, Statue of the Owner, False Door. The *rooms* are specified as: Entrance, Courtyard, Niche Entrance, Pillared Hall and Sanctuary. For the definition of *preservation*: well, moderate, not well, unfinished or destroyed and not existing are proposed. Not existing is in use, if a scene is not documented, cannot be stated due to its preservation state or was never finished and engraved.

Fig. 7 gives an example of the collected data. The additional R package ggplot2 by H. Wickham is used to create data visualizing charts. A scatterplot can be realized for each monument to display as much information about a scene as possible in one chart but can also be omitted. The example of Ankh Hor (8) shows that many different decoration categories are located in the courtyard, a room

accessible and lit (5). The prepared data frame allows to question more detailed quantitative problems relating the distribution of the scenes in the analyzed monument. The relation between scene categories and their occurrences in the rooms as arguments of an aesthetic mapping (aes) are questioned in 9. Additionally, the factor() function is used to integrate the information of the monument and the preservation status, which is illustrated by different colors and shapes (9). The chart likewise shows a density of scenes in the courtyard of the monuments. It also reveals that the topic of the scenes at the niche entrances is limited to offering scenes. An information that emphasizes the importance of this part of the complexes. The results for the pillared hall state a density of texts to support the diseased to afterlife. In this context the pillared hall of Irtieru stands out from the collected data. The chart shows the location of a false door in the pillared hall. However, a false door would be expected in a more public place, because it was the place to place offerings for the deceased. Moreover, offering scenes and representations of the owner in the pillared hall of the complex of Irtieru stand out, because these scenes are not known for the pillared halls of the other monuments. Possibly the ongoing excavations at Irtieru will prevent new insights to these results. Fig. 10 shows a related chart with information about the preservation status and scene category in the monument and room. With this graph, information about the location of a scene in a monument is revealed easily. It states that most of the well preserved decorations are located in the monuments of Harwa, Pabasa and Ankh Hor. It is also able to reflect the bad preservation status of Irtieru and Karabasken.

category	room	monument	preservation
Daily Life Scene	Courtyard	Anch Hor	well
Daily Life Scene	Courtyard	Harwa	well
Daily Life Scene	Courtyard	Pabasa	well
Daily Life Scene	Courtyard	Akhimenru	not existing
Daily Life Scene	Courtyard	Karabasken	unfinished or destroyed

Figure 7: *Example of a dataset.*

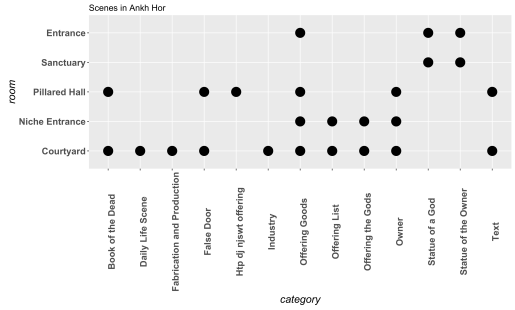

Figure 8: *Scatterplot diagram of scenes in the monument of Ankh Hor.*

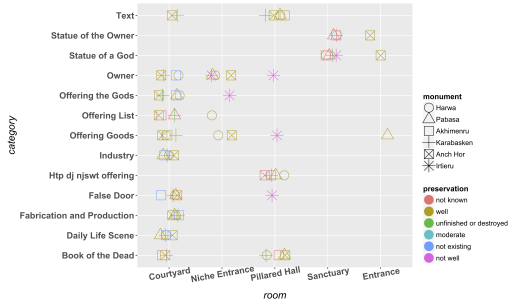

Figure 9: *The preservation status of a scene in a room, including additional information of the monument (Note: variables are jittered to minimize overplotting)*

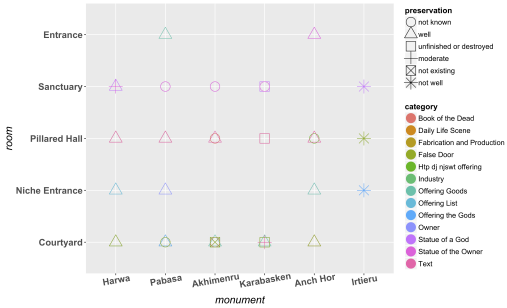

Figure 10: *Information about the preservation status and scene category in the monuments and rooms.*

6. Conclusion and Outlook

This paper provides two possible methodologies for quantitative and comparative studies of decoration of a group of ancient funerary monuments. First, the use of scene-category tags, color labels and the visualization in a real-time 3D development platform was chosen. This solution provides a user friendly and interactive information interface to locate and compare decorations in 3D models. With the implemented color markings scene categories are easily highlighted by the user to locate the position of the according decor. Second, statistical computing is applied to receive adequate quantitative information. The results of both methodologies are consistent and indicate a strong connection between the spatial structure, space utilization and decoration program. The visual analysis as well as the statistical evaluation reveal uniform results.

Naturally lit and accessable spaces like the courtyard show scene categories concerning the monument's owner and his life. Scenes of industrial fabrication as well as scenes showing the owner and offerings are frequently found in this area. On the other hand the closable rock-cut structure is concentrating on texts. This quantitative result corresponds with the spatial analysis, which indicates an increasing sacred intensity in the deeper parts of the monuments.

For future work more monuments can be included into the analysis. Also the category list of scenes can be further detailed. Concerning visual analysis, additional schematic graphs to differentiate the scenes can be included. For statistical purposes the orientation of the scenes in the room can be added. This extension of the data can easily be achieved thanks to the prepared dataset. Additional information can be included and new queries can be started.

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